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STUDIES ON SOME ASPECTS OF REPRODUCTIVE BIOLOGY OF ONE STRIPE SPINY EEL MACROGNATHUS ARAL (BLOCH AND SCHNEIDER, 1801) – AN IMPORTANT FRESHWATER ORNAMENTAL FISH

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ABSTRACT

The current study presents fundamental information on the reproductive biology of *Macrognathus aral* (Bloch and Schneider, 1801). The comparative pattern of the reproductive biology dealing with sex ratio, maturation of gonads, gonadosomatic index ova-diameter and fecundity of freshwater one stripe spiny eel, *Macrognathus aral* were investigated. The overall M: F ratio was recorded as 1:1.65. Both male and female fishes were mostly mature in May-July. The peak value of gonadosomatic index in female was observed in June (13.94) and in male during July (1.44) indicating that the fish is an annual breeder. The range of ova diameter varied from 0.34-1.38 mm; absolute fecundity ranged from 372.4 - 5781.4. The 50% maturity is attained in length group of 191 – 210 mm for males and 231 – 250 mm for females. The relationship between fecundity and body weight and length has also been discussed.

KEYWORDS: *Macrognathus aral*, gonadal maturation, gonadosomatic index, sex ratio, fecundity, ova-diameter.

INTRODUCTION

The freshwater one stripe spiny eel, *Macrognathus aral* is an inland water teleostean fish commonly known as peacock eel among aquarium hobbyists. The species is distributed to India, Pakistan, Bangladesh, Srilanka, Myanmar and Nepal (Talwar and Jhingran, 1991). It has a long and eel-like body type with a long fleshy snout and a rounded caudal fin that is separated from dorsal and anal fins. In live condition, body color is brownish to yellowish ventrally and presence of two distinct long dark bands on either side of body. There are 3-11 ocelli (false 'eye' spots) at the base of dorsal fin. The IUCN red list 2012 enlists this fish in the 'least concern' category while as per Conservation Assessment and Management Plan (CAMP) Report (1998) it is included under "Lower Risk near threatened" (LRnt-category) in India.

Modes of reproduction in fishes present an extreme diversity related to the vast number of species and to the large range of aquatic environments inhabited (Jalabert, 2005). Reproductive Ecology of any fish is essential for assessing commercial potentialities of its stock, life history, culture practice and actual management of its fishery (Lagler, 1956).

Fecundity, spawning, sex ratio etc are among the important aspects of the biology of fishes which must be understood to explain the variations in the level of populations as well as to make efforts to increase the amount of harvest (Azadi, 1996). Reproductive potential of a population is one of the basic exigencies to designate the individuals of that population in respect to their gonadal conditions (Jhingran , 1972). Knowledge of gonadal development and the spawning season of a species allow subsequent studies on spawning frequency of its population, which is important for its management (Chakrobarty, 2007). A few investigations have been carried out on various biological aspects of different species belonging to family Mastacembelidae. Swarup et al. (1972) studied on sexual dimorphism of *M. pancalus.* Karim and Hossain (1972) investigated the general biology of *M. pancalus* (Ham.) in artificial ponds and also studied the sexual maturity and fecundity. Kocetov (1992) reported on few aspects of reproductive biology of spiny eels. Narejo et al. (2002) studied on the ova diameter, gonadosomatic index, and fecundity of *Mastacembalus armatus* in Bangladesh. Serajuudin and Ali (2005) described the feeding habits of *Macrognathus pancalus*. Chavan et al., (2006) made an effort on the conservation of spiny eel, *Mastacembalus armatus.* Suresh et al. (2006) carried out their study on certain aspects of biology and fisheries of *M. pancalus* from Ganga river system. Serajuddin and Mustafa (1994) and Serajuudin *et al.* (1998) investigated the food and feeding habits of *Mastacembelus armatus.* Rahman and Miah (2009) conducted a study on fecundity of *Mastacembelus pancalus*. However, except for the work of Biswas and Abujam (2011), no such significant work on the biological aspects of *Macrognathus aral* has not yet been carried out in West Bengal. Hence, the present study was aimed at investigating some of the significant aspects of reproductive biology of *Macrognathus aral.*

MATERIALS AND METHODS

After collection in field, specimens were packed in ice box and brought to laboratory. Total length of each individual specimen was measured to the nearest of 0.1 cm using a standard measuring scale and total weight was measured to the nearest of 0.01 gm using an electronic balance (Sartorius, Model No. BT 223S). In *Macrognathus aral* it is not easy to discriminate sex externally apart from a small duration of the breeding period by observing the swollen belly of the female fishes; so in the present study sex was determined by examination of the gonads. Gonads were dissected out carefully and moisture on the surface of gonads was removed with blotting paper. The length and weight of gonads were measured to the nearest of 0.1 cm and 0.01 gm.

Monthly variation in sex ratio has been studied after counting the total number of males and females in the monthly collected samples. Chi-square test was done to explore the differences in sex-ratio (monthly and over-all value) from the expected ratio of 1:1.

Macroscopic and microscopic studies were performed to investigate the cycle of gonadal maturation. Different maturation stages of male and female gonads were grouped into different gonadal stages of development (Nikolsky, 1963).Other information for discrimination of gonadal maturity stages was obtained by looking into the work of Azadi and Mamun (2004). Immature gonads were very similar in morphological appearance; hence acetocarmine squash technique (Guerrero and Shelton, 1974) was used to confirm the true identity of gonads.

Gonad mounts were examined under streoscopic microscope for identification. Male gonads exhibited fine granular like structure of spermatogonia while femal gonads show presence of circular oogonia.

Gonadal length index (GLI) was determined following the methodology of Azadi and Mamun (2004). Gonadosomatic index was determined according to Narejo et al. (2002).

Size frequency distribution of the intra-ovarian oocytes has been studied following the methodology of LeCren (1951). Monthly changes in ova diameter was recorded with an ocular micrometer. To find out the length at first sexual maturity, after measurement of the total length (TL), specimens have been grouped in different size groups with interval of 20 mm.The size group, in which at least 50% of the fish specimens have been observed to be with mature gonad, has been regarded as length at first sexual maturity (Suresh, 2006; Mitra, 2007). Studies on fecundity of *Macrognathus aral* (Bloch and Schneider) were carried out following the methodology of MacGregor **(**1922**).**

RESULT

Study of gonadal maturation stages

Gonadal maturation stages of ovary in *Macrognathus aral* (Bloch and Schneider)

Stage I (immature): Ovaries thin, faint pink colored, thread like in appearance and semi transparent in nature.

Stage II (maturing or recovering spent): Ovaries become swollen and elongated. Reddish yellow in color or greenish in some. Small ova, visible to bare eye, started to appear.

Stage III (mature): Ovaries become distinctly voluminous and bright yellow or green colored with a slight lobular appearance. Ovaries contain ova with distinct yolk.

Stage IV (ripe): Ovaries occupy almost 3/4th of abdominal cavity. Ova are bright green in color and the compact arrangement of ova become somewhat loose.

Stage V (spent): Ovaries become shrunken, with drastic reduction in both length and weight, showing a pale white colored sac like appearance.

Gonadal maturation stages of testis in *Macrognathus aral* (Bloch and Schneider)

Stage I (immature): Testes narrow, thread like, white and translucent in nature.

Stage II (maturing): Testes shows slight increase in length with a little bulbous appearance. Appearance of indistinct vasa differentia.

Stage III (mature): Testes become swollen and creamy white in color. Vasa differentia is distinct.

Stage IV (spent): Testes become dried up showing decrease in both length and weight.

In females, immature gonads appeared from September to March with highest percentage in October. Stage II or maturing gonads were observed from October to June, highest percentage being in April. Females with mature gonads appeared from April to August with highest percentage in May. Ripe or stage IV ovaries were noticed from May to July with highest percentage in July. Spent ovaries appeared from July to September with peak percentage being observed in August. [Fig: 1.A]

In males, stage I or immature testes were observed from September to April, hitting the highest percentage in December. Maturing testes were observed from December to July with a maximum percentage in May. Males with mature testes were observed from April to September with highest percentage in June. Spent testes were observed from July to November with peak percentage in August. [Fig: 1.B]

Study of sex ratio

Out of the 1,501 specimens examined, 934 were female and 567 were male. The overall sex ratio for the pooled observations for male: female was 1:1.65. Taken as a whole, females have revealed to be significantly dominant ($p<0.01$) over males. However, when examined on the basis of monthly records, the difference in number of male and female, was not significant for the month of November, December, February, March, May, June and September during the observation period November 2010- October 2011. During observation period, November 2011 – October 2012, December, January, March, May, June and August were the months showing no significant difference between male and female. (Table:1.A-B)

Study of length at first maturity

Females having mature gonads first appeared in the 170-190 mm size group. Size group 231—250mm was considered to be the group where above 50% of females were present with mature gonads. Size group 251-270mm shows the highest percentage of females with mature ovaries. The smallest males with mature gonads appeared in size group 150-170mm. size group 191-210mm was the group where more than 50% of males were with mature testes. Highest percentage of males with mature testes was observed in size group 211-230mm. [Fig: 1.C-D]

Study of gonadal length index

In female fishes, gonadal length index reaches its peak value in July and then starts decreasing and reaches lowest value in November. In males, highest value of GLI was observed in July and lowest in November. [Fig: 1.E-F]

Study of gonadosomatic index

In females GSI was observed to reach its highest value in June (for study period November 2010-October 2011) and in July (for study period November 2011-October 2012). Then it drastically reduces attaining lowest value in August. Then it shows a gradual but steady increase from September to March. From April GSI starts to increase in a rapid manner and attains peak value in June or July. In males, GSI attained its peak value in July (for both years) and then following a decline reaches lowest value in September. Then it shows a trend of gradual increase till April. From May, GSI shows quick increase reaching highest value in July. [Fig: 1.G-H]

In females, GSI shows significant relationship with total length (TL), total weight (TW) and gonad weight (GW). Relationships are expressed by the following equations-

$\text{Log GSI} = 3.6101 \text{ Log TL} - 7.6989 \quad [r^2 = 0.15; p<0.01]$

$\text{Log GSI} = 0.9059 \text{ Log GW} + 0.3568 \quad [r^2 = 0.44; p<0.01]$

$\text{Log GSI} = 1.3545 - 0.3589 \text{ Log TW} \quad [r^2 = 0.07; p<0.05]$

In males, GSI also shows significant relationships with total length, total weight and gonad weight. Relationships are as follows-

$\text{Log GSI} = 2.7628 \text{ Log TL} - 6.3010 \quad [r^2 = 0.41; p<0.01]$

$\text{Log GSI} = 1.1746 \text{ Log TW} - 1.7189 \quad [r^2 = 0.28; p<0.01]$

$\text{Log GSI} = 0.9239 \text{ Log GW} + 0.4979 \quad [r^2 = 0.72; p<0.01]$

Study of fecundity

Fecundity in *Macrognathus aral (Bloch and Schneider)* varied between 622.49±226.96 to 4511.73±498.59 [Fig: 1.I-J]. Fecundity (F) shows significant positive correlation with total length (TL), total weight (TW) and gonad weight (GW). Relationships are expressed by the following regression equations-

$\text{Log F} = 4.5855 \text{ Log TL} - 7.5229 \quad [r^2 = 0.49; p<0.01]$

$\text{Log F} = 1.2632 \text{ Log TW} + 1.3129 \quad [r^2 = 0.45; p<0.01]$

$\text{Log F} = 0.887 \text{ Log GW} + 3.0514 \quad [r^2 = 0.95; p<0.01]$

Study of ova diameter and size frequency distribution of ova

Ova were classified into four size groups; immature (0.34-0.50mm), maturing (0.51-0.80mm), mature (0.81-1.10) and ripe (1.11-1.38mm). The frequency of occurrence of ova belonging to different size groups plotted against months have revealed that immature ova were observed from March to May with highest percentage in March. Maturing ova occurred from March to July with peak value in May. Mature ova were observed from April to July with highest percentage in June. Ripe ova first appeared in May and were seen till July when it reached its peak value. [Fig: 1.M-N]

Monthly average diameter of ova varied between 0.49±0.12 to 1.16±0.21 (mm).Ova diameter shows progressive increase from March to July with ripe ova displaying the highest values. [Fig: 1.K-L]

Table: 1.A. Monthly variation in sex ratio of *Macrognathus aral* (First year)

Month	No. of fish with gonads.	Male Observed value		Female Observed value		Ratio of male and female	χ 2	Remark
		No.	%	No.	%			
Nov 2010	67	28	41.79	39	58.21	1:1.39	1.5	NS
Dec 2010	72	31	43.05	41	56.94	1:1.32	1.12	NS
Jan 2011	69	25	36.23	44	63.77	1:1.76	4.7	S*
Feb 2011	58	26	44.83	32	55.17	1:1.23	0.44	NS
Mar 2011	62	29	46.77	33	53.22	1:1.14	0.14	NS
Apr 2011	66	21	31.82	45	68.18	1:2.14	8.02	S**
May 2011	53	24	45.28	29	54.72	1:1.20	0.3	NS
June 2011	47	19	40.42	28	59.57	1:1.47	1.36	NS
July 2011	51	18	35.29	33	64.71	1:1.83	3.84	S*
Aug 2011	52	15	28.85	37	71.15	1:2.47	8.48	S**
Sept 2011	59	23	38.98	36	61.02	1:1.56	2.44	NS
Oct 2011	63	22	34.92	41	65.08	1:1.86	5.14	S*

Table: 1.B. Monthly variation in sex ratio of *Macrognathus aral* (Second year)

Month	No. of fish with gonads.	Male Observed value		Female Observed value		Ratio of male and female	χ 2	Remark
		No.	%	No.	%			
Nov 2011	74	25	33.78	49	66.22	1:1.96	7.14	S**
Dec 2011	72	28	38.89	44	61.11	1:1.57	3.12	NS
Jan 2012	75	30	40.00	45	60.00	1:1.5	2.62	NS
Feb 2012	68	23	33.82	45	66.18	1:1.96	6.48	S*
Mar 2012	70	31	44.29	39	55.71	1:1.26	0.7	NS
Apr 2012	65	22	33.85	43	66.15	1:1.95	6.16	S*
May 2012	52	20	38.46	32	61.54	1:1.6	2.32	NS
June 2012	56	22	39.29	34	60.71	1:1.54	2.16	NS
July 2012	48	16	33.33	32	66.67	1:2	4.68	S*
Aug 2012	60	26	43.33	34	56.67	1:1.31	0.82	NS
Sept 2012	69	19	27.54	50	72.46	1:2.63	13.04	S**
Oct 2012	73	24	32.88	49	67.12	1:2.04	7.9	S**

[χ^2= Chi-square; NS = not significant; S* = significant at 5% level; S = significant at 1% level]**

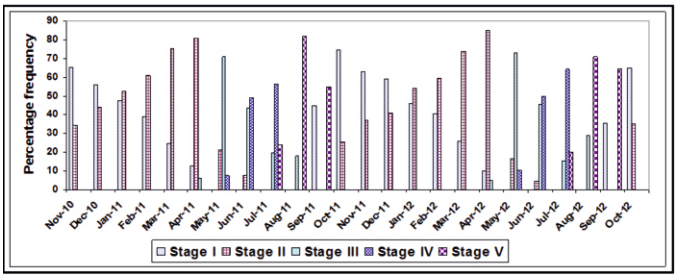

Fig.1.A. Monthly percentages of gonadal maturation stages in *Macrognathus aral* female

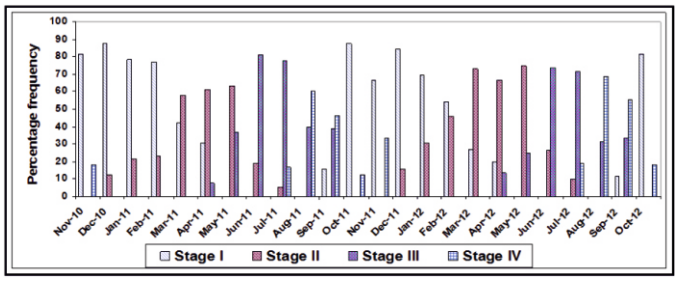

Fig.1.B. Monthly percentages of gonadal maturation stages in *Macrognathus aral* male

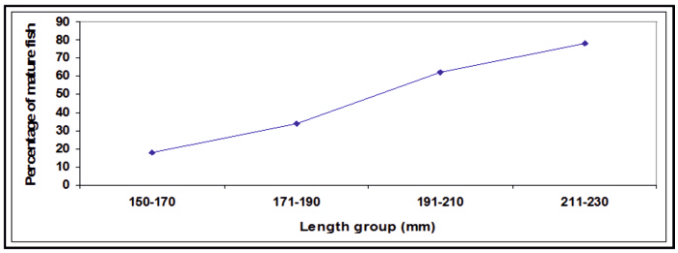

Fig.1.C. Percentage of mature fish in different length groups of male Macrognathus aral

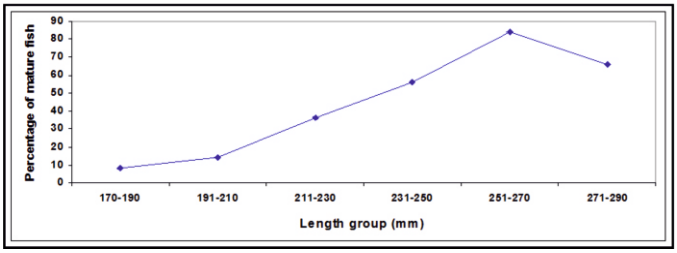

Fig.1.D. Percentage of mature fish in different length groups of female *Macrognathus aral*

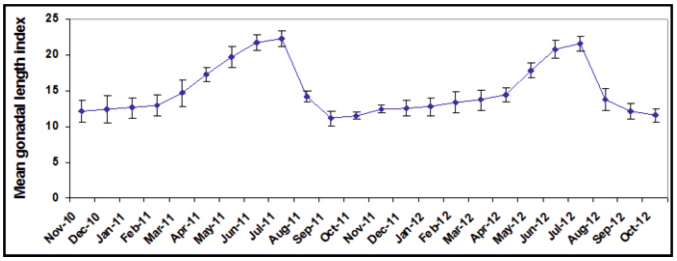

Fig.1.E. Annual variation in gonadal length index of Macrognathus aral male

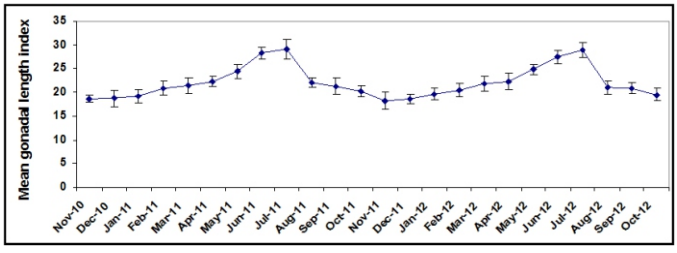

Fig.1.F.Annual variation in gonadal length index of *Macrognathus aral* female

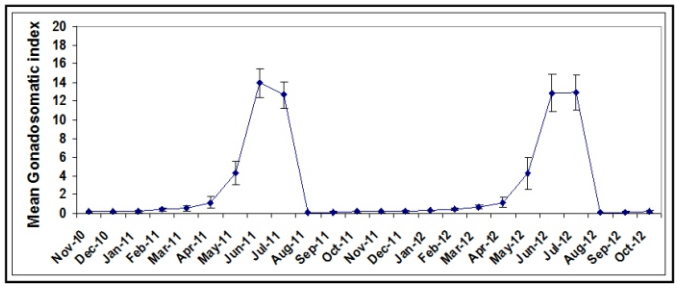

Fig.1.G..Annual variation in gonadosomatic index of Macrognathus aral female

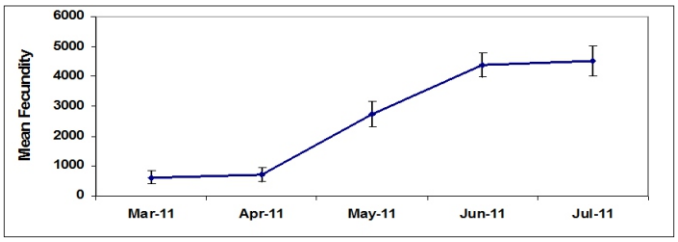

Fig.1. I. Variation in mean fecundity of *Macrognathus aral*

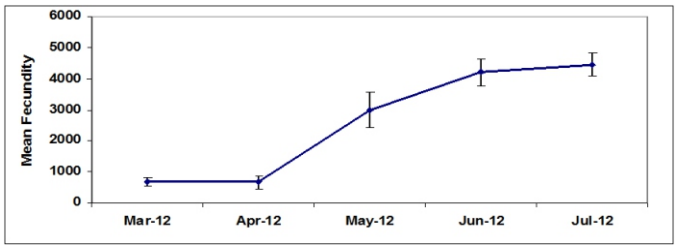

Fig.1. J.Variation in mean fecundity of *Macrognathus aral*

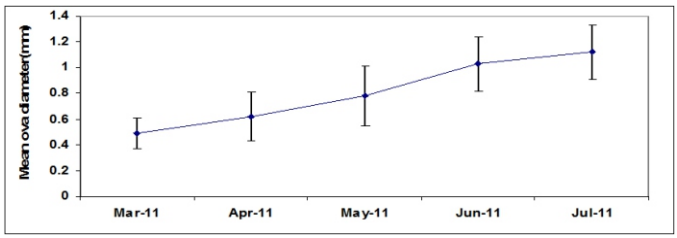

Fig.1.K..Variation in mean ova diameter of *Macrognathus aral*

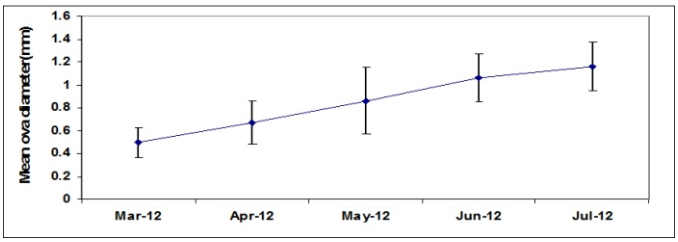

Fig.1.L.Variation in mean ova diameter of *Macrognathus aral*

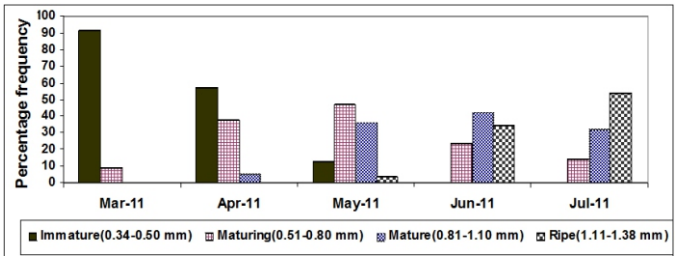

Fig.1.M.Percentage of four size groups of intra-ovarian ova in *Macrognathus aral*

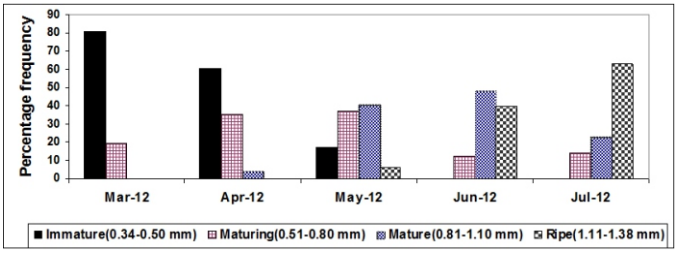

Fig.1. N.Percentage of four size groups of intra-ovarian ova in *Macrognathus aral*

DISCUSSION

Analysis of sex ratio reveals the deviation of sex ratio from the expected 1:1 value and the dominance of females over males. Previous workers have also found similar results while studying other fish species. (Suresh et al. 2006; Azadi et al. 2004; Pathak et al., 2012; Ravi Shankar et al., 1986; Mondal et al.,2010; Olurin et al.,2011.). The elevated metabolic strain of spawning in older males as reported by previous workers (Ursin, 1963; Cooper, 1983) can be a probable cause of mortality in males. However, according to Fagade et al., (1984) the natural mechanism of population regulation can be the reason behind the existence of excess amount of females.

Monthly variation in GSI indicates both different phases of reproductive cycle and duration of spawning season. Maximum values of both GSI and ova diameter were recorded in the month of June and July indicating a single spawning season. Study on fecundity reveals the species to be moderately fecund. Fecundity increased with total length and total weight of the fish. Previous workers found the same trend in other fish species (Kabir et al., 1998; Narejo, 2003).

Study on length at first maturity reveals that males mature earlier than females. Previous workers have also reported this trend in other fish species which supports the present observation (Suresh et al., 2006; Babu et al., 1983; Rao and Sharma, 1984; Banik et al., 2012). Length at first sexual maturity is extensively used as an indicator of minimum-permissible capture size (Lucifora et al., 1999). The results of the present study have revealed that the minimum capture size for *Macrognathus aral* male is 211 mm and for female it is 251 mm.

CONCLUSION

The present study on reproductive biology of *Macrognathus aral* has revealed the followings –

i) Female are dominant over males in the wild population of this species.

ii) Males mature earlier than females.

iii) Cyclic changes in the maturation and depletion of gonads, intra ovarian oocytes and gonadosomatic index in *Macrognathus aral* clearly indicated that breeding was synchronous with the beginning of monsoon (June – August) and this species spawn only once in a year.

iv) Fecundity in *Macrognathus aral* was significantly correlated with total length and total weight of the fish.

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